GAS SPRING DAMPER UNIT FOR A MOTOR VEHICLE

BACKGROUND OF THE INVENTION

[0001] The Invention relates to a gas spring damper unit for a motor vehicle comprising a cylinder casing and a cylinder piston shiftable in the cylinder casing and having a piston rod, wherein the cylinder piston is sealed relative to the cylinder casing by a sealing element and wherein the piston rod is connected to the cylinder casing by rolling bellows, where by a spring damper chamber becoming smaller upon spring compression and a damper chamber becoming larger upon spring compression are formed, wherein the two chambers are connected by a throttle acting in two directions and disposed in the cylinder piston and wherein this throttle comprises one or several overflow throttles.

[0002] Gas spring damper unit of this kind are employed predominantly in the motor vehicle technology, for example for the wheel suspension or also for a spring supported driver seat.

[0003] Gas spring damper units are in principle known in a three chamber construction with a spring chamber carrying the load and two oppositely disposed damper chambers as well as with a two chamber construction having a combined spring damper chamber and a damper chamber on the other hand.

[0004] A gas spring damper unit in the two chamber construction is known for example from the German printed Patent document DE 3641623 A1. This two chamber gas spring damper unit is provided for a wheel suspension and comprises a cylindrical casing with a cover and a double acting piston fitted into the casing. The piston has a piston rod on one side, wherein the piston rod penetrates the cover of the casing. The casing on the one hand and the piston rod on the other hand are solidly connected to one body part or, respectively, to the wheel suspension, wherein the freely disposed part of the piston rod is covered by bellows. For this purpose, the bellows are attached

on the one hand to a cover of the casing and on the other hand at the head of the piston rod.

[0005] The piston subdivides the cylinder chamber of the casing into a decreasing pressure chamber and an increasing pressure chamber during spring compression, wherein one of the pressure chamber is connected toward the outside with a compressed air source through a casing connector and wherein the pressure chambers are connected to each other through one or several overflow throttles disposed in the piston.

[0006] These overflow throttles are formed out of a plurality of simple axial throttle bore holes, wherein the throttle bore holes are disposed on a circle concentric with the center axis of the cylinder piston 4 and wherein the throttle bore holes have the same throttling effect relative to the balancing air stream in two directions of motion. The piston motion is thereby damped to the same extent in both directions. This is disadvantageous because of the required floor attachment of the wheels there is desired a smaller damping motion for the spring compression as compared to the spring decompression. A further disadvantage is based on the situation that the throttle bore holes represent constant throttles and therefore work depending on the speed of the cylinder piston. This means that the increase in the throttling effect decreases with increasing piston speed.

[0007] These requirements are met by an overflow throttle which is shown in the German printed Patent document DE 8413300 U1. This overflow throttle comprises a central throttle bore hole with an annular chamber, wherein the annular chamber is covered by a flexible ring disk. This ring disk heads on the one hand an outer stop face and on the other hand an inner stop face, such that the ring disk lifts off from the respective stop face in one flow-through direction at the outer rim and in the other flow-through direction at the inner rim. Different lever arms result by the different distance of the two stop faces relative to the center of the ring disk, wherein the different lever arms effect a different opening characteristic for the two flow-through directions. In case of a

proper selection of the spring force of the ring disk, the throttling effect and there with the damping force remains equal over the complete speed range of the cylinder piston.

[0008] The overflow throttles require however a large technical production expenditure, since initially very complicated channel guidings are required. In addition, the ring disk has to be held and guided in a most difficult way such that the outer edge region and the inner edge region of the ring disk perform alternatively a sealing function or holding function. This again increases the costs of production. It is to be added that an additional part is required with the ring disk, which also effects negatively on the production costs. It is a deficiency in a functional perspective that the ring disk is a moving part, which is subject to wear and therefore has only a limited lifetime.

[0009] Therefore it is an object of the present Invention to develop a gas spring damper unit of the kind recited, which has an about equal remaining damping force over the complete speed range of the cylinder piston, which has a different damping behavior in the two directions of motion of the cylinder piston and which is simple and cost favorably produceable.

SUMMARY OF THE INVENTION

[0010] These and other objects and advantages of the present invention are achieved by providing a gas spring damper unit with specifically shaped overflow throttles whose locations of greatest throttle effect are located in an axial position of the cylinderl piston that is outside the radial plane through the axial middle of the cylinder piston and all on the same side of this plane.

[0011] The particular advantage comprises here that the advantages of a throttle opening with a closure element and the advantages of an open throttle opening are combined. Thus there are present open bottle openings present at the new overflow throttles, wherein the open talk to openings are not subject to wear and therefore not

sensitive to interference and exhibit an unlimited lifetime. The expenditure for production of the new overflow throttles is small.

[0012] Functionally it is accomplished that the gas passes through the overflow throttles at small loads of the cylinder piston with a laminar kind of flow. The therewith obtained damping forces are also relatively small because of the small pressure difference over the overflow throttles and because of the small pressure losses based on the laminar flow. This is an advantage. The pressure difference over the overflow throttles increases with higher loads of the cylinder piston and therewith also the flow resistances increase. The laminar flow changes into a turbulent flow based on the special construction and dimensioning of the overflow throttles at the pre-calculated load of the cylinder piston, whereby the flow resistance is additionally increased. This additional flow resistance increases again the desired damping forces in the upper speed range of the cylinder piston. This is also desired and an advantage.

[0013] Reference can be made to all known and possible possibilities for the particular construction of the overflow throttles, which possibilities have influence on the overall flow resistance. Amongst these are for example of the length, the cross-section, the cross-section shape, the longitudinal shape, and in the material and the surface properties of the wall of the overflow throttles.

[0014] The locations of the functionally greatest throttle effect of the flow resistances of at least two of the overflow throttles can in a particular way be displaced outside of the radial plane through the axial middle of the cylinder piston, and then different flow resistances and therewith different damping forces occur for the two directions of flow. This is also desired and always then an advantage, where different speeds are required for the two directions of motion of the cylinder piston.

[0015] The invention both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the

accompanying drawings, in which several of the various possible embodiments of the present invention are shown.

[0016]

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In the drawings,

[0018] Fig. 1 shows a gas spring damper unit in a two chamber construction in a sectional view,

[0019] Fig. 2 shows the piston of a gas spring damper unit in a top planar view,

[0020] Fig. 3 shows a first embodiment of an overflow throttle,

[0021] Fig. 4 shows a second embodiment of an overflow throttle,

[0022] Fig. 5 shows a third embodiment of an overflow throttle,

[0023] Fig. 6 is a sectional view of a prior art nozzle , and

[0024] Fig. 7 is a view similar to that of Fig. 3 with additional designations.

DETAILED DESCRIPTION OF THE DRAWINGS

[0025] As shown in Fig. 1, the two chamber gas spring damper unit has a cylinder casing 1 with a casing foot 2 on the one hand side and the casing cover 3 on the other hand side. The casing foot 2 is connected to the vehicle body or to the wheel suspension over elements not illustrated here. An axially shiftable guided cylinder piston

4 with a piston rod 5 and the roll off piston 6 is disposed in the cylinder casing 1. The piston rod 5 and the roll off piston 6 are solidly connected to each other and jointly penetrate the casing cover 3 of the cylinder casing 1.

[0026] The piston rod 5 and the roll off piston 6 are dimensioned in their radial extensions such that a throttle free annular channel 7 remains between the roll off piston 6 and the casing cover 3. This annular channel 7 is pressure tight closed toward the outside by an air spring bellows 8, wherein the air spring bellows 8 comprises a long wearing and flexible material and which air spring bellows 8 are on the one hand attached to the casing cover 3 and on the other hand to the piston rod 5. This air spring bellows 8 exhibits such a spatial extension that the bellows form a bellows chamber 9 outside of the cylinder casing 1 and seals the cylinder casing 1 with this bellows chamber 9. The piston rod 5 is furnished with a hollow chamber 10 for reasons of shortening the incorporation height, wherein the hollow chamber 10 at its space has a force engagement face 11 for connecting to the vehicle body or to the wheel suspension.

[0027] The cylinder piston is furnished at its circumference with a sealing element 12, whereby the inner chamber of the cylinder casing 1 is subdivided into a spring damper chamber 13 becoming smaller upon spring compression and into a damper chamber 14 becoming larger upon spring compression.

[0028] This damper chamber 14 is connected to the bellows chamber 9 through the already mentioned annular channel 7. Several overflow throttles 15 are disposed in the cylinder piston 4, wherein the overflow throttles 15 corner the spring damper chamber 13 and the damper chamber 14 in a particular way to each other. An external gas source in connection with a gas connector not specially shown takes care that a predetermined gas pressure is built up and is maintained in the inner chambers of the gas spring damper unit.

[0029] Fig. 2 shows a selected arrangement of these overflow throttles 15, wherein all overflow throttles 15 are disposed on a circle concentric with the center axis of the cylinder piston 4 and are placed at a uniform distance from each other.

[0030] These overflow throttles 15 have the purpose to enable a volume balancing between the spring damper chamber 13 and the damper chamber 14 in case of corresponding motions in the two directions of the cylinder piston 4 and therewith to obtain a damped motion of the cylinder piston 4 by a throttling of the passing through gas stream. Correspondingly, the one or several overflow throttles 15 are attuned in their cross-section, their length and their shape in a particular way to the respective application situation. The overflow throttles 15 perform furthermore the task to develop different throttle effects in the two flow through directions and therewith to develop different damping forces.

[0031] In connection therewith, the Figs. 3 through 5 show a selection of corresponding embodiments.

[0032] According to Fig. 3, an overflow throttle is furnished as a cylindrical bore hole with a cylindrical cross-section narrowing 16 and a cylindrical cross-section expansion 17. A conical cross-section 18 is disposed between the cross-section narrowing 16 and the cross-section expansion 17, wherein the conical cross-section 18 adapts slowly and continuously in diameter to the cross-section narrowing 16 and the cross-section expansion 17. If several of hese overflow throttles 15 are arranged in the cylinder piston, they are aligned such that all cross-section narrowings 16 are disposed outside of the radial plane through the axial middle of the cylinder piston 4 (see Fig. 7) and on the same side of this plane.

[0033] According to Fig. 4, an overflow throttle 15 comprises a bore hole with a first conical cross-section 19 and a second conical cross-section 20, wherein the two conical cross-sections 19 and 20 are disposed opposite to each other in the kind of a Laval nozzle. The two cross-sections 19,20 are connected to each other through a rounded

cross-section narrowing 21. This rounded cross section narrowing 21 is disposed in the region outside of the radial plane through the axial middle of the cylinder piston 4, that is outside of the half length of the throttle of the overflow throttle 15. If several of hese overflow throttles 15 are arranged in the cylinder piston, preferably the rounded cross-section narrowings 21 of these overflow throttles 15 are disposed on the same side of the radial plane through the axial middle of the cylinder piston 4.

[0034] In Fig. 5, the overflow throttle 15 is a conical bore hole 22 extending in axial direction through the entire cylinder piston 4. Preferably the conical bore holes 22 of all overflow throttles 15 are disposed in the same direction.

[0035] It is common to all embodiments of overflow throttles shown in Figs. 3 to 5 and derivable thereof that all sizes and values influencing the flow resistance such as length, cross-section, geometric cross-sectional shape for the surface the properties of each overflow throttle 15 are furnished such that the characterizing critical Reynold number, characterizing the transition of the laminar flow kind into the turbulent flow kind of the gas, is disposed within the pressure differences over the overflow throttle 15, which pressure differences can occur based on the different speeds of the cylinder piston 4. Here are certain number or all overflow throttles 15 are furnished with cross-sectional narrowings 16, 21, which are always disposed outside of the radial plane through the axial middle of the cylinder piston 4 and on the same side of this plane. Preferably, the axial location of greatest flow resistances of the overflow throttle (15) is disposed on the side of the smaller becoming spring damper chamber (13). The selection of the number of the overflow throttles equipped with a cross-sectional narrowing 16, 21 depends in the case of a desired and uniform force distribution also on the uniform distribution on the circle concentric with the center axis of the cylinder piston 4.

[0036] The over flow throttle according to Fig. 6 exhibits a radial plane through the axial middle of the cylinder piston 4 at half height level (y) of the cylinder piston which, at the same time, represents a radial plane perpendicular to the bore hole axis and disposed

in the axial middle of the bore hole. The state of the art throttle of Fig. 6 exhibits the same throttle resistance and therewith the same damping force independent of the direction of flow in the bore hole of the throttle. Therefore, the location (x) of the functionally greatest throttle effect of the overflow throttle is disposed at half the length of the throttle bore hole. Therefore, according to the prior art example, the axial location of the functionally greatest throttle effect (x) of the over flow throttle is disposed on the radial plane through the axial middle (y) of the cylinder piston 4.

[0037] The Fig. 7 shows the asymmetrical bore hole throttle according to the present invention, where the largest cross-section narrowing is placed at the edge of the cylinder piston such that the axial location of the functionally greatest throttle effect (x) adjusts itself to become located outside of the radial plane (y) through the axial middle of the cylinder piston 4. Different flow resistances and thereby different damping forces result depending on the direction in which the flow passes through the over flow throttle. The different damping forces are intended with gas spring damping units.

[0038] Constant, i.e. unchangeable, throttle shapes can be associated with the disadvantage that the throttle effect does not increase in the same measure as the stroke speed of the cylinder piston increases. In order to eliminate this disadvantage, the bore hole of the throttle should be constructed that the type of flow switches from laminar to turbulent at a certain piston speed. This kind of turbulent flow generates an additional and desired flow resistance, where the increase of the flow resistance adapts in its slope again to the increase in piston speed.

[0039] The subject matter of the present invention distinguishes from the overflow throttles shown in Fig. 6.The throttles according to Fig. 6 are employed as several axially directed throttle bore holes of uniform diamerter, which exhibit equal throttle effects in the two possible flow through directions. The overflow throttles according to Fig. 6 are simple constant value throttles, which are working depending on the speed of the cylinders. This means that an increase in the throttling effect becomes smaller with increasing piston speed.

[0040] This feature is not desirable with gas spring damper units. It is desirable to furnish a gas spring damper unit having an about equally remaining damping force over the complete speed range of the cylinder piston. This effect is essentially accomplished with a spring loaded overflow throttle.

[0041] The bore hole of the throttle according to the present invention with the cross-sectional narrowing furnishes such a flow resistance, wherein the flow resistance is such that upon a certain speed of the piston the type of flow of the gas jumps from laminar flow to turbulent flow. This turbulence accomplishes an additional flow resistance, wherein the additional flow resistance retains the increase in throttling effect constant also in the upper region of the piston speed.

The overflow throttle (15) according to the present invention has a difference of flow resistance such that the flow resistance in a higher flow resistance direction is at least about 5 percent higher as the flow resistance in a lower flow resistance direction. Preferably, the flow resistance in the higher flow resistance direction is at least about 30 percent higher as the flow resistance in the lower flow resistance direction. More preferably, the flow resistance in the higher flow resistance direction is at least about 100 percent higher as the flow resistance in the lower flow resistance direction. Even more preferred is the situation, where the flow resistance in the higher flow resistance direction is at least about 500 percent higher as the flow resistance in the lower flow resistance direction.

[0042] According to the present invention, the cone face angle relative to the longitudinal axis of the bore hole of the throttle in Figs. 3 and/or 5 can be from 10 degrees to 70 degrees and preferably from 30 to 60 degrees and more preferably from 40 to 50 degrees. In a diameter changing bore hole of a throttle as shown by way of example in Figs. 3, 4 and 5, the diameter of the bore hole can change from a lower opening to an upper opening by a ratio of from 1 to 10 up to a ratio of 1 to 1.2 and is preferably in a range of from 1 to 5 up to 1 by 2 and preferably in a range of 1 to 4 up to

1 to 3. Alternatively, in an opening face changing bore hole of a throttle, the diameter can change from a lower opening to an upper opening by a ratio of from 1 to 50 up to a ratio of 1 to 1.5 and is preferably in a range of from 1 to 20 up to 1 by 4 and preferably in a range of 1 to 10 up to 1 to 6.

[0043] In a curved bore hole according to Fig. 4, the curvature can be convex as is shown in Fig. 4 and alternatively concave. The size of the radius of curvature in an axial section of the bore hole as for example shown in Fig. 4 from 0.5 times the thickness of the piston plate or the length of the bore hole to 10 times The length of the bore hole and the radius of curvature is preferably from 1 times the length of the bore hole to 5 times the length of the bore hole.

[0044] The flow mass in the direction of less flow resistance of the bore hole can be from about 1.2 to 20 times the gas weight throughput in the direction of higher flow resistance and is preferably from 3 to 10 times the gas weight throughput of the direction of higher flow resistance at the relevant piston speeds of concern.

[0045] List of Reference Characters

[0046] 1 cylinder casing
[0047] 2 casing foot
[0048] 3 casing cover
[0049] 4 cylinder piston
[0050] 5 piston rod
[0051] 6 roll off piston
[0052] 7 annular channel
[0053] 8 air spring bellows
[0054] 9 bellows chamber
[0055] 10 hollow chamber
[0056] 11 force engagement face
[0057] 12 sealing element
[0058] 13 spring damping chamber

[0059] 14 damping chamber

[0060] 15 overflow throttle

[0061] 16 cross-section narrowing

[0062] 17 cross-section expansion

[0063] 18 conical cross-section

[0064] 19 first conical cross-section

[0065] 20 second conical cross-section

[0066] 21 rounded cross-section narrowing

[0067] 22 conical bore hole